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Finance and Business Operations Division
Procurement and Contract Services Section
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Pervious Pavement

INTRODUCTION

Porous pavement is a permeable pavement surface, often built with an underlying stone reservoir that temporarily stores surface runoff before it infiltrates into the subsoil. Porous pavement replaces traditional pavement, allowing stormwater to infiltrate directly into the soil. There are various types of porous surfaces, including porous asphalt, pervious concrete and even grass or permeable pavers.

Types of permeable paving

Typical applications for permeable paving include industrial and commercial parking lots, sidewalks, pedestrian and bike trails, driveways, residential access roads, and emergency and facility maintenance roads.

Porous Concrete

Pervious concrete is similar to conventional concrete, except the mixture contains little or no sand, creating void space – between 15% and 25%. Pervious concrete allows 3 to 8 gallons of water per minute to pass through each square foot of the material. By allowing rainwater to seep into the ground, pervious concrete can facilitatel in recharging groundwater and reducing stormwater runoff. This capability can reduce the need for retention ponds, swales, and other stormwater management devices.

Use of pervious concrete is among the Best Management Practices (BMP) recommended by the EPA and other agencies for the management of stormwater runoff. By eliminating the need for retention ponds, swales, and other stormwater devices, pervious concrete can lower overall project costs and makes more efficient use of the land.

Porous Asphalt

Porous asphalt has 20 – 30% void space as opposed to standard asphalt which usually has about 2 – 3% void space when compacted. These pavements, used mostly for parking lots, allow water to

drain through the pavement surface into a stone recharge bed and infiltrate into the soils below the pavement.

Another important element is the subbase material, as the water needs a place to go. The size and depth of the stone bedding must be designed so that the water level never rises into the asphalt.

Concrete Pavers

This material can be used to create a porous surface with the aesthetic appeal of brick, stone, or other interlocking paving materials. They are most often used for driveways, entryways, walkways, or terraces. These pavers can be solid, but allow water to drain through the spaces between the pavers. Or they can be a grid system which can be filled with vegetation or aggregate depending upon the need. These products have good strength properties.

Plastic Grid System

High strength plastic grids (often made from recycled materials) are designed to be filled with gravel on top of an engineered aggregate material. Some are filled with a sand/soil mixture on top of an aggregate/topsoil mix that allows grass to be planted on the surface. The grids provide a support structure for heavy vehicles, and prevent erosion.

USAGE HISTORY AND EXPERIENCE

King County Roads Division has experience with both porous concrete and asphalt. All of these projects were designed to use porous material to allow water to flow through, instead of allowing storm water to run down the sidewalk and into storm drains or other drainage systems. Testing by the King County Roads Division Materials Lab showed good strength properties.

In 2007, Roads did a low-impact development project that included an 1100 sq. yard porous concrete sidewalk and a rain garden that reduces the amount of impervious surfaces and helps maintain the natural hydrology of the site. It will also lower the cost of stormwater infrastructure by eliminating the need for a retention vault or pond.

In 2008, Roads Division built a roundabout at an intersection to ease the flow of increased traffic traveling to and from a new development and school. Low impact development stormwater management techniques included using porous concrete cement for new sidewalks at the intersection, and using native, drought-resistant shrubs and trees in the roundabout's center.

In 2008, Roads Maintenance and Operations used approximately 210 square feet of porous concrete to build a sidewalk. Engineers specifically designed the project to use porous concrete as it is located in a sensitive area above Lake Washington.

In 2004, Roads Division built a porous asphalt bike path which is shared by cyclists and pedestrians. Water that falls on the path soaks through to the soil underneath and filters into the groundwater naturally. Porous asphalt has 20 – 30% void space as opposed to standard asphalt which usually has about 2 – 3% void space when compacted. By using the porous asphalt the county did not have to build an additional percolation pond, a savings of about $ 50,000.

BID AND CONTRACT SPECIFICATIONS

King County Pervious Concrete Sidewalk

This specification was used in two 2008 Roads projects. The specification was enhanced by the Roads Environmental Unit as lessons were learned from a 2007 project. This specification will continue to be revised as King County gains experience.

8-33.1 DESCRIPTION

This Work consists of constructing 6-inch thick pervious cement concrete (Class 4000) sidewalks, and integral ADA accessible ramps in accordance with details shown in the Contract Documents, and these Specifications and in conformity to the lines and grades shown in the Plans or as established by the Engineer.

8-33.2 MATERIALS

The concrete in the sidewalks shall be air entrained pervious cement concrete Class 4000 in accordance with the requirements of Section 6-02.

Gravel Backfill for Drywell shall conform to requirements as identified in Section 9-03.12(5) of the Standard Specifications.

Portland Cement Type I or II conforming to ASTM C150 or Portland Cement Type IP or IS conforming to ASTM C595.

Flyash conforming to ASTM C618 may be used in amounts not to exceed 20-percent of total cementitious material. Ground Iron Blast Furnace Slag conforming to ASTM C989 may be used in amounts not to exceed 50-percent by weight of total cementitious material.

Aggregate: No. 8 coarse aggregate (3/8-inch to No. 16) per ASTM C33; or No. 89 Coarse aggregate (3/8-inch to No. 50) per ASTM D448. If other gradation of aggregate is to be used, submit data on proposed material to the Engineer for approval.

Air Entraining Agent: Shall comply with ASTM C260.

Admixtures:

Type A Water Reducing Admixtures – ASTM C494
Type B Retarding – ASTM C494
Type D Water Reducing/Retarding – ASTM C494

A hydration stabilizer can be utilized and is recommended in the design and production of pervious concrete. This stabilizer suspends cement hydration by forming a protective barrier around the cementitious particles, which delays the particles from achieving initial set. The admixture's primary function should be as a hydration stabilizer; however, it must also meet the requirements of ASTM C494 Type B Retarding or Type D Water Reducing/Retarding Admixtures.

Water: Water used in pervious cement concrete shall be potable.

8-33.2(1) MIXTURE PORPORTIONING

The composition of the proposed concrete mixtures shall be submitted to the Engineer for review and/or approval and shall comply with the following provisions, uncles an alternative composition is demonstrated to comply with the project requirements.

1. Cementitious Content: For vehicle pavements, total cementitious content shall not be less than 630 lbs/cy. For pedestrian pavements, total cementitious content shall not be less than 600 lbs/cy.
2. Supplementary Cementitious Content: Fly Ash: 20% maximum. Slag: 50% maximum.
3. Water / Cementitious Ratio: Maximum 0.30 for vehicle pavements and 0.35 for pedestrian pavements.
4. Aggregate Content: The bulk volume of aggregate per cubic yard shall be equal to 27 cubic foot when calculated from the dry rodded density (unit weight) determined in accordance with ASTM C29 jugging procedure. Fine aggregate,

if used, should not exceed three (3) cubic feet and shall be included in the total aggregate volume.

5. Admixtures: Admixtures shall be used in accordance with manufacturer's instructions and recommendations.

6. Mix Water: The quantity of mixing water shall be established to produce a pervious concrete mixture of the desirable workability to facilitate placing, compaction and finishing to the desired surface characteristics. Water mix shall be such that the cement paste displays a wet metallic sheen without causing the paste to flow from the aggregate. (Mix water yielding a cement paste with a dull-dry appearance has insufficient water for hydration.)

Insufficient water results in inconsistency in the mix and poor bond strength. High water content results in the paste sealing the void system primarily at the bottom and poor surface bond.

8-33.3 CONSTRUCTION REQUIREMENTS

8-33.3 (1) EXCAVATION

Excavation shall be made to the required depth and to a width that will permit the installation and bracing of the forms. Side slopes adjacent to the sidewalk shall be shaped to a 2:1 slope to match existing grade unless otherwise specified. The foundation shall be shaped and compacted to a firm even surface conforming to the section detail shown in the Plans. All soft and yielding material shall be removed and replaced with acceptable Gravel Backfill for Drain material.

8-33.3 (2) SUBGRADE

a. Material: The top 12-inches shall be composed of Gravel Backfill for Drain.

b. Permeability: Subgrade material shall have a minimum permeability of 0.5-inch per hour determined in accordance with ASTM D3385.

c. Compaction: Compact the subgrade to a minimum 90% and a maximum 95%. Over-compaction can inhibit subgrade percolation. Compaction shall be in accordance with ASTM D1557.

d. Fill: If fill material is required to bring the subgrade to final elevation, it shall be clean and free of deleterious materials. It shall be placed in 6-inch maximum layers, and compacted by a mechanical vibratory compactor to a minimum of 90% in accordance with ASTM D1557.

e. Moisture: The subgrade moisture content shall be 1%-3% above the optimum as determined by ASTM D1557.

8-33.3 (3) FORMWORK

Forms shall be of wood or metal and shall extend for the full depth of the concrete. All forms shall be straight, free from warp, and of sufficient strength to support mechanical equipment without deformation of plan profiles following spreading, strike-off and compaction operations. All form work shall also resist the pressure of the concrete without springing or deforming. Bracing and staking of forms shall be such that the forms remain in both horizontal and vertical alignment until their

removal. After the forms have been set to line and grade, the foundation shall be brought to the grade required and thoroughly wetted approximately 12 hours before placing the concrete.

Apply form release agent to the inside face of all formwork before placing pervious cement concrete.

Formwork may have a removable spacer of ½" to ¾" thickness placed above the depth of pavement. The spaces shall be removed following placement and vibratory strike-off to allow roller compaction.

Existing utility or valve covers, frame and grates, detectable warning panels, project plaques, and other features in or adjacent to the concrete sidewalk placement shall be protected by plastic (firmly attached to the feature using duct tape) or other approved means, as is necessary to protect them from concrete. If inadequate protection permits concrete to splatter, marr, obscure, or damage the feature, the Contractor shall, at no expense to the County, clean it or remove and replace it with material that the Engineer approves.

Important Note:

The Contractor shall seal all formwork to ensure containment of concrete and cement-laden water and shall provide a substantial physical barrier (3/4-inch plywood or other approved means) extending from existing ground to an elevation a minimum of 3 feet above the back of walk capable of preventing the inadvertent spillage or splatter of cement concrete materials. The barrier may be part of and an extension above the formwork. Formwork shall be sealed at the base and joints to prevent seepage of cement-laden water. Where the barrier is a separate and distinct element, plastic covering shall also be used between the barrier and the back of forms to seal the barrier. All cement-laden material shall be removed from this zone and the Contractor shall take all precautions necessary to ensure that no cement-laden water is discharged. The Contractor shall be responsible for the design and performance of formwork during concrete placement and curing.

8-33.3 (4) BATCHING AND CARTING

There shall be no headwater or residual water remaining in the truck before batching the materials. Batch sizes shall be limited to a maximum of 7 cubic yard. There is no required minimum batch size.

Pervious concrete shall be manufactured and delivered in accordance with ASTM C94.

Mixtures shall be produced in central mixers or in truck mixers. When concrete is delivered in agitating or non-agitating units, the concrete shall be mixed in the central mixer for a minimum of 1.5-minutes or until a homogenous mix is achieved. Concrete mixed in truck mixers shall be mixed at the speed designated as mixing speed by the manufacturer for 75-100 revolutions.

The pervious concrete mixture may be transported or mixed on site and discharge of individual loads shall be completed within one (1) hour of the introduction of mix water to the cement. Delivery times may be extended to 90-minutes when a hydration stabilizer is used.

Each truckload will be visually inspected for consistency of concrete mixture. Water addition is permitted at the point of discharge to obtain the required mix consistency

provided by measurable quantity is used before more than 0.5 cubic yard of concrete is discharged. A minimum of 30 revolutions at the manufacturer's designated mixing speed shall be required following the addition of any water to the mix. Discharge shall be a continuous operation and shall be completed as quickly as possible. Concrete shall be deposited as close to its final position as practical and such that discharged concrete is incorporated into previously paced plastic concrete.

8-33.3 (5) SPECIAL EQUIPMENT

Pervious concrete requires specific equipment for compaction and jointing. The pavement shall be jointed and compacted using the methods listed:

a. Rolling compaction shall be achieved using a minimum 10-inch diameter steel pipe that spans the width of the section placed and exerts a vertical pressure of at least 10 psi on the concrete.

b. Plate compaction shall be achieved using a standard soil plate compactor that has a base area of at least two square feet, and exerts a minimum of 10 psi vertical pressure on the pavement surface.

c. When joints are placed in pervious pavements, they shall be constructed by rolling or sawing. Rolled joints shall be formed using a "Salt Roller" to which a beveled fin with a minimum depth of 1½-inch has been welded around the circumference of a steel roller. Sawed joints shall be constructed using an early entry or wet saw.

8-33.3 (6) PLACING AND FINISHING CONCRETE FOR PERVIOUS CEMENT CONCRETE SIDEWALK

Truck mixers shall be operated at the speed designated as mixing speed by the manufacturer for 75 to 100 revolutions of the drum.

The portland cement aggregate mixture may be transported or mixed on site and shall be used within one (1) hour of the introduction of mix water, unless otherwise approved by the Engineer.

Each mixer truck will be inspected for appearance of concrete uniformity. Water may be added to obtain the required mix consistency. A minimum of 20 revolutions at the manufacturer's designated mixing speed shall be required following any addition of water to the mix. Discharge as close to its final position as practicable and such that fresh concrete enters the mass of previously placed concrete. The practice of discharging on to the subgrade bed and pulling or shoveling to final placement is not allowed.

The subgrade bed shall be in a moist condition when (within ±3-percent of the optimum moisture content as determined by the modified compaction test ASTM D 1557 or ASSHTO T180).

Deposit pervious concrete directly from the transporting equipment onto the subgrade bed.

Do not place pervious concrete on frozen subgrade or subbase.

Deposit pervious concrete between the forms to a uniform height.

Do not use an internal vibrator to consolidate the pervious concrete.

Spread the concrete using a come-along, short-handle, square-ended shovel or rake.

Unless otherwise accepted by the Engineer in writing, the Contractor shall strike off the pervious concrete between forms using a vibrating screed. Vibration shall be shut off immediately when forward progress is halted for any reason.

Immediately after strikeoff, compact concrete to elevations and thickens specified in the plans by means of a full-width roller that provides a minimum compactive vertical force of 10psi.

Minimize foot traffic within plastic concrete during the spreading, strikeoff and compaction operations to eliminate excessive consolidation of the material.

No other finishing operation other than jointing is required after compaction.

Maximum placement width is 15-feet unless successfully demonstrated otherwise and accepted by the Engineer.

Construct the pervious concrete to comply with the following tolerances:

Thickness: +3/8 inch, -1/4 inch

Surface: In any direction, the gap below a 10-foot unleveled straightedge shall not exceed ½-inch

Joints: Contraction Joint Depth +1 1/2-inch, -0 inch

Joint Width: +1/8-inch, -0 inch

Areas of new sidewalk where conflicts with utility facilities or appurtenances prevent completion of the work shall be blocked off 2.5 feet either side of the conflict and filled with compacted CSBC. A closure pour shall be made after the relocation of the conflicting utility has been completed.

8-33.3 (7) JOINTING

Contraction joints shall be installed at 10-foot intervals and in conjunction with the expansion joints placed in the curb and gutter, as shown in the Plans. Contraction joints shall be installed at a maximum depth of 1 ½-inch. These joints shall be installed in the plastic concrete, or saw cut after the concrete has hardened.

Contraction jointing plastic concrete shall be constructed utilizing a roller as described in the Special Equipment section of this specification. This operation shall be performed immediately after the roller compaction and prior to curing.

Jointing hardened concrete saw cuts shall be made as soon as the pavement has hardened sufficiently to prevent raveling and uncontrolled cracking. Early entry sawing occurs later with pervious concrete than with conventional concrete. For either method, the curing cover shall be removed and the surface kept misted to prevent moisture loss. After sawing the curing cover shall be securely replaced for the remainder of the curing cycle.

Transverse construction joints shall be installed whenever placing is suspended for 30-minutes or whenever concrete is no longer workable. Construction joint material shall be 3/8-inch thick, be full depth of the pervious concrete section, and conform to the requirements in Section 9-04.1.

Isolation joints shall be used when abutting fixed vertical structures such as light pole bases, building foundations, etc. Isolation material shall be positioned before concrete is placed and shall be the full depth of the pavement section.

8-33.3 (8) CURING

Curing procedures shall begin immediately after final placement operations have been completed. The pavement surface shall be covered with a minimum of six (6) mil thick polyethylene sheet or other approved covering material. Prior to covering, a fog shall be sprayed above the surface when required due to ambient conditions (temperature, wind, and humidity). For additional guidance on hot weather concreting, see American Concrete Institute (ACI) Circular 305.

The low water/cement ratio and high amount of exposed surface of pervious concrete makes it especially susceptible to drying out. Immediately after screeding, the surface shall be kept moist and evaporation prevented using a spray applied curing compound and/or evaporation retarder immediately after screeding.

The cover shall overlap all exposed edges and shall be secured (without using dirt or stone) to prevent dislocation due to winds or adjacent traffic conditions.

The curing cover shall remain securely in place for a minimum of 7 days. No vehicular traffic shall be permitted on the pavement until curing is complete and no truck traffic shall be permitted for at least 14 days. The County has the option of permitting earlier traffic opening times.

8-33.3(9) QUALITY CONTROL

At least one member, or 20% of the crew (whichever is greater) shall be certified by National Ready Mixed Concrete Association (NRMCA) Certified Pervious Concrete Technician. All certified personnel shall remain onsite, overseeing all placement crew members during pervious concrete placement operations. The Contractor shall submit to the Engineer copies of the required certificates for Pervious Concrete Technician personnel prior to the commencement of Work on the project.

The Pervious Cement Concrete Installation Contractor shall use adequate numbers of skilled workers who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work as specified. Traditional portland cement pavement testing procedures based on strength and slum control are not applicable to this type of pavement material.

Before any pervious concrete material is incorporated into the work, the material shall be visually inspected for uniform mixing and the correct moisture content. Material which does not meet visual inspection shall be rejected and shall not be included in the Work. If the Engineer determines that the material has excessive balls it will be rejected. Material that is excessively wet or dry shall be rejected. When the concrete is at the correct moisture content a small sample can be compressed by hand to form a shape which will remain after compression. With

slight bouncing the compressed concrete will break in to several large pieces. No consideration for payment of any sort will be given for rejected material.

Concrete tests shall be performed for each 150 cubic yards or fraction thereof, with a minimum of one test for each day's placement.

Plastic concrete shall be sampled in accordance with ASTM C172, and density (unit weight) measure in accordance with ASTM C138. The density (unit weight) of the delivered concrete shall be +/-5 pcf of the design density (unit weight).

Plastic void content shall be calculated as per ASTM C138, Gravimetric Air Determination and compacted to the void percentage require by the hydraulic design. Unless otherwise specified, Void content shall be between 15% and 25%.

Hardened concrete shall be tested at a rate of one set of three cores per 150 cubic yards of concrete placed on one day, or fraction thereof. The cores shall be drilled in accordance with ASTM C42. The cores when measured for length shall not be more than ½-inch less than the specified design thickness.

The cores shall be tested for density (unit weight) and void content using ASTM C140. Density (unit weight) shall be +/-5 pcf of the design unit weight. Void content shall not be greater than 2% below the specified design void content. Void content shall be calculated as follows:

% Voids = 1 – (Dd/Di) * 100
where: Dd = oven dried density of core
Di = immersed density of core

Before final acceptance by the County, the Contractor shall pressure wash the pervious concrete sidewalk. The pressure washing shall be completed by a washer working at a minimum of 3000 psi and 1.0 gpm. The nozzle shall be held a maximum of 3 inches off the concrete. The Contractor shall wash the entire top surface of the pervious concrete sidewalk. Any sections of pervious concrete that breaks up, pits or does not infiltrate shall be removed and replaced with acceptable pervious concrete. The approximate minimum infiltration rate required is 10 inches per hour. The Engineer shall be solely responsible for determining the acceptability of the concrete after pressure washing.

The Contractor may decide how soon after placing the pervious concrete that they perform the quality assurance testing for the County's acceptance.

8-33.3 (10) CONCRETE TRUCK WASHOUT

The Contractor shall provide a washout trough, such as the Eco-Pan washout containment system (http://www.eco-pan.com/), to ensure complete containment of all waste concrete materials and cement laden water; or shall ensure that all concrete truck washouts occurs off-site at the concrete plant. The concrete truck washout area shall not be located near any storm drain inlets, drainage structures, or within any stream buffer or sensitive area within or adjacent to the project site. Containment facilities shall be approved by the Engineer prior to being used for concrete truck washout. If washouts are done off-site, disposal tickets shall be transmitted to the Engineer within two working days.

8-33.3 (11) TEST PANELS

Regardless of qualification, the Contractor shall complete a satisfactory test panel to demonstrate their ability to place pervious concrete sidewalk, before placing the rest of the pervious concrete sidewalk as required in the Contract. The test panel is to be a minimum of 40 feet and a maximum of 80 feet long and to the dimensions of the project's sidewalk. The maximum size of the test panel shall be one ready-mix truckload. The test panel shall be placed, jointed and cured using materials, equipment, and personnel proposed for the project, at a location specified to have pervious concrete sidewalk installed. The test panel shall be cured for 7 days and then inspected and tested for acceptance.

The test panels shall have acceptable surface finish, joint details, thickness, porosity and curing procedures and shall comply with the testing and acceptance standards listed in these specifications.

If test panels placed at the site are found to be deficient in thickness, density (unit weight) or percentage of voids, or of an unacceptable appearance, they shall be removed at the Contractor's expense and taken to an approved landfill or recycling facility. If test panels are found to be satisfactory, the may be left in-place and included in the completed Work.

The test panel shall be acceptable if the pervious concrete material is placed to the lines and grades shown in the plans, if the material has sufficient infiltration capacity and strength. The Engineer shall be solely responsible for determining the acceptability of the test panel.

Upon acceptance of the test panel by the Engineer the rest of the remaining portions of Work may be installed. If the test panel is determined to be unacceptable by the Engineer, the test panel shall be removed and disposed of in an appropriate manner. Payment for the removal, haul and disposal of the test panel materials shall be considered to be incidental to the bid item "Pervious Cement Concrete Sidewalk (Class 4000) 6-Inch Thick Incl. Excavation."

8-33.4 MEASUREMENT

"Pervious Cement Concrete Sidewalk (Class 4000) 6-Inch Thick Incl. Excavation" will be measured by the square yard of finished surface area.

8-33.5 PAYMENT

Payment will be made in accordance with Section 1-04.1 of the Standard Specifications for the following Bid item when included in the proposal:

"Pervious Cement Concrete Sidewalk (Class 4000) 6-Inch Thick Incl. Excavation", per square yard.

The unit Contract price per square yard for "Pervious Cement Concrete Sidewalk (Class 4000) 6-Inch Thick Incl. Excavation" shall be full compensation for all labor, equipment, and material necessary to complete the installation of pervious cement concrete sidewalk.

Installation of polyethylene sheet shall be considered to be incidental to the pervious concrete sidewalk work, and the costs thereof shall be included in the unit Contract price for "Pervious Cement Concrete Sidewalk (Class 4000) 6-Inch Thick Incl. Excavation." No separate or additional payment will be made.

It shall also include protecting all sidewalks from damage and vandalism until accepted by the Owner. The Contractor shall further provide verbal and written notice (door hanger) to property owners identifying restricted use of the sidewalk, etc. This notice must be provided one-week prior and again one-day prior to the Work being performed.

City of Seattle

Porous Concrete Specification
Porous Asphalt Specification

City of Olympia

Pervious Concrete Sidewalks

FOR MORE INFORMATION

2007 King County Military Road Project

Porous Pavement Fact Sheet – US EPA

City of Chicago Green Alleys Handbook

"Green Paving Grows Beyond Parking Lots" – Better Roads

Asphalt – the right choice for porous pavements

Green Parking Lots (City of Seattle)

LID Manual - Low Impact Development Technical Guidance Manual on our website: Section 6.3 (pages 107-111) covers permeable systems

Pervious Concrete Pavement – (National Ready Mixed Concrete Association)

Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring Fact Sheet - Porous Pavements

National Asphalt Pavement Association (NAPA) - Porous asphalt

Permeable Paver Specification – Low Impact Development Center

VENDOR INFORMATION

Ecostone

GrassPave2

GravelPave2

Ecogrid